SEEDS

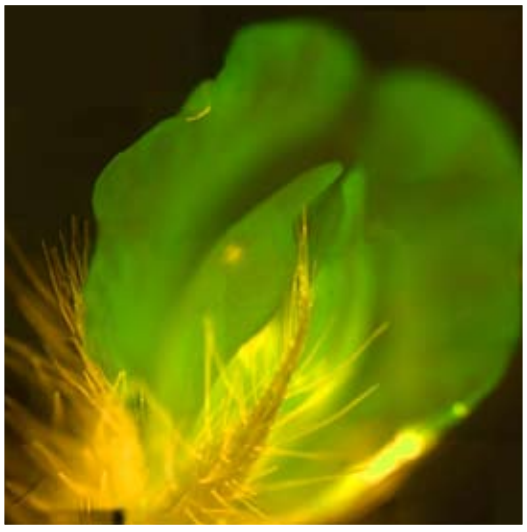
SEEDS: The OARDC Research Enhancement Competitive Grants Program

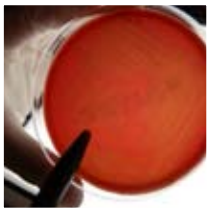
Report of Progress

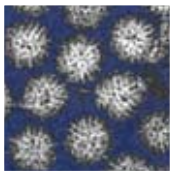
for Calendar Year 2006

Ohio Agricultural Research and Development Center

The Ohio State University







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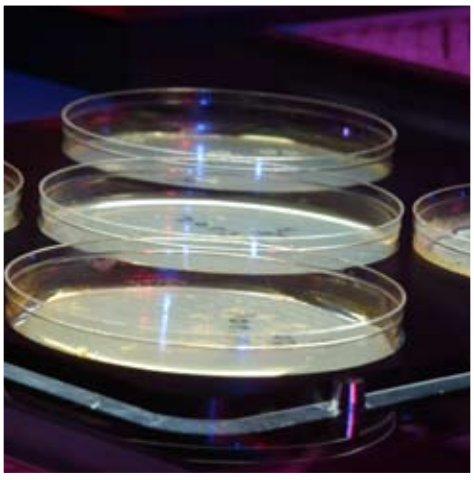

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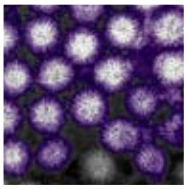

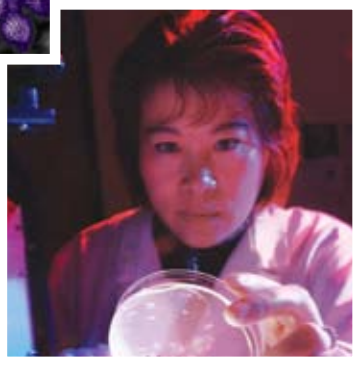

Current and Past Industry Partners

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Alpaca Jack's Suri Farm
American Aggregates Corp.
American Coal Ashland Association
American Hosta Society
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SEEDS: The OARDC Research Enhancement Competitive Grants Program

No other economic engine in Ohio comes close to making the kind of impact generated by agriculture, food, and the nursery and landscape industry. After all, this industry yields more than $80 billion annually, employs one in every six Ohioans, and supports a diversified and dynamic economic sector that touches the lives of everyone in the state.

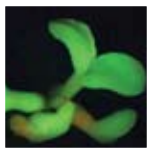
Those who work in and benefit from this industry — producers, processors, and consumers — rely on quality, state-of-the-art research to help them deal effectively with multiple and varied challenges that come along the way. Those challenges may include livestock and crop production issues, packaging and product development, and food safety and nutrition.

With the changing nature of the economy and the impact of globalization, agriculture, food, and the green industry also look to innovation to generate new processes or products and increasingly link with other industries to take on common challenges and opportunities — in key areas such as environmental restoration or the development of bio-renewable sources of energy, fuel, and industrial goods.

Addressing the challenges and opportunities of Ohio's largest industry is the ultimate goal of SEEDS: The Research Enhancement Competitive Grants Program. SEEDS promotes excellence in Ohio Agricultural Research and Development Center (OARDC) research, promoting research consistent with the mission and vision of OARDC and encouraging connections across disciplines and with industry and other external partners. Citizens in Ohio and around the world benefit from this work.

Established in 1996 and supported by an appropriation from the Ohio General Assembly to OARDC, SEEDS: The Research Enhancement Competitive Grants Program is unique among U.S. state-assisted universities. In fostering high-quality research among OARDC- and College of Food, Agricultural, and Environmental Sciences (CFAES)-supported scientists, SEEDS enables those scientists to collect preliminary data needed to give them a competitive edge in national programs and provides them with leverage to attract industry support.

Since the program's inception, faculty have submitted 843 applications, of which 324 were funded. A total of 228 projects are now complete. The program's return on investment continues to exceed expectations: For every OARDC dollar invested in the SEEDS program, $5.22 has been returned as a result of industry matches and extramural funding.



Objectives

SEEDS was created to encourage partnerships with industry and other stakeholders and to increase the competitiveness of OARDC/CFAES scientists in extramural grant programs. While these objectives remain the program's cornerstone, SEEDS has grown to include a total of seven objectives, each with measurable objectives.

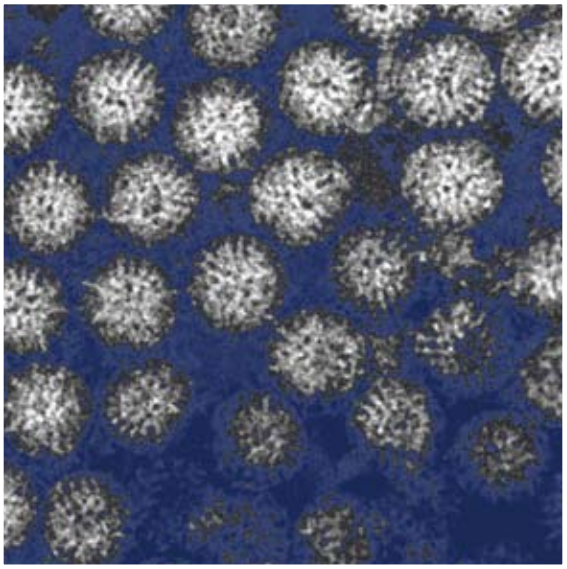
- Increase the competitiveness of scientists in extramural grant programs.
- Encourage partnerships with industry and other stakeholders
- Encourage the development of interdisciplinary teams.
- Encourage international collaborations.
- Support the exploration of enterprises that are potentially new to Ohio.
- Provide undergraduate students with research experience.
- Provide graduate students with the opportunity to take part in the grant-writing/review process.

By providing seed money to develop the necessary preliminary data for a strong grant application or by matching funds to leverage external funding, SEEDS has proved to be a valuable program for scientists in the College of Food, Agricultural, and Environmental Sciences. The SEEDS program looks forward to continued success and new partnerships with industry and other collaborators in Ohio and the world within the context of our global society.

Program Achievements

Overall, SEEDS has supported research projects in the amount of $7,366,645 in all categories and has received $38,460,804 in matching and extramural funding — a return of $5.22 for each dollar invested.

- Invested $1,644,858 in projects requiring matching funds, generating $3,326,362 in industry matches — a return of $2.02 on each dollar invested.
- Enabled scientists to establish collaborations with colleagues from Africa, Argentina, Australia, Belgium, Brazil, Chile, France, New Zealand, Norway, the Philippines, Switzerland, Taiwan, Uganda, and Zimbabwe.
- Applications have been made for nine U.S. patents using results of initial findings. Two patent applications have been granted, one has been approved on a provisional basis, and three licensing agreements have been obtained.
- A total of 295 scientific manuscripts and abstracts have been published and 607 presentations made throughout the world. In 2004 extra data were collected on completed projects — an additional 262 manuscripts were reported and 495 presentations were reported, bringing the program totals to 557 manuscripts and 1,102 presentations.
- SEEDS-supported graduate students have produced 24 doctoral dissertations and 58 theses.



Achievements by Objectives

Objective 1 — Increasing the competitiveness of scientists in extramural grant programs.

The Seed Grant Competition and the Agency External Competitions specifically address Objective 1. However, all of the other competitions may result in additional funding from outside sources.
Of the 20 projects completed and reported in calendar year 2006, $1,054,140 was generated in extramural funding.
Over the life of SEEDS, 228 projects have been completed, and $32,513,858 has been generated extramurally.
Over the life of SEEDS, OARDC has invested $480,362 in matching funds for Agency External Grants which generated $2,888,938 in extramural funding.

Objective 2 — Encouraging partnerships with industry and other stakeholders.

The Matching and Industry Small Grant Competitions address Objective 2.
Of the eight grants requiring at least a dollar-for-dollar match and completed during calendar year 2006, OARDC provided a total of $119,211 while industry matched these dollars with $164,555.
For the life of the program, 99 Matching and Industry Small Grants have been completed with OARDC providing $1,644,858 while industry matched these dollars with $3,326,362 — a return of $2.02 on each dollar invested.

Objective 3 — Encouraging the development of interdisciplinary teams.

The Interdisciplinary Team Competition specifically addresses Objective 3.
During calendar year 2006, three interdisciplinary teams completed projects. These teams reported receiving $382,000 in extramural funding.
Over the life of the program, six colleges and 23 departments have participated in 34 completed projects with OARDC investing $3,146,498 and teams competing successfully for $7,969,618 in extramural funding — a return of $2.53 on each dollar invested.

Objective 4 — Encouraging international collaborations.

All competitions may have an international collaboration component, and international relationships are encouraged. Fifty-five proposals have been submitted to this competition since 1999.
OARDC scientists have collaborated with scientists from Africa, Argentina, Australia, Belgium, Brazil, Chile, France, Italy, New Zealand, Norway, the Philippines, Switzerland, Taiwan, Uganda, and Zimbabwe.

Objective 5 — Support the exploration of enterprises that are potentially new to Ohio.

New Enterprises are considered to be crops, animals, products, goods, and services that currently are not produced for biological, physical, cultural, processing, economic, or social reasons. The New Enterprise Competition is designed to explore new enterprises and to eliminate the barriers that constrain existing ones.
The New Enterprise Competition has received a total of 23 applications; seven have been funded.

Funded projects include:

- Development of a New Biological Product for Slug Control.
- Direct Conversion of Agricultural Wastes to Electricity Using Rumen Microbes in Microbial Fuel Cells.
- Functional Properties of Ohio Soybean Varieties in New Heart Healthy Bakery Products.

Objective 6 — Providing undergraduate students with research experience.

A total of 37 applications to the Director's Undergraduate Research Program have been received. Twenty-seven applicants have received awards.

The Director's Undergraduate Research Program provides undergraduate students with a professional grant writing, research, and reporting experience. Projects are designed, submitted for review, and carried out with a faculty mentor. Once the project is completed, students take an independent studies class to write their research report in the form of a scientific journal article, using their faculty advisor as an editor. Some of these reports have been published. In addition, many students present their research at professional meetings and at competitions such as the Denman Undergraduate Research Forum, a university-wide program presented by the Ohio State University Office of Research and the University Honors and Scholars Center.

Examples of research recently funded in the Undergraduate Competition include:

- Evaluation of the Effectiveness and Behavior of Two Innovative Storm Water Management Practices.
- The Effects of Vitamin E with Weaned Pigs.
- Preventing Obesity in Children by Educating Parents about the Importance of Fruit and Vegetable Intake.

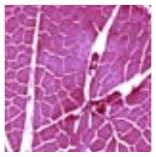
Objective 7 — Providing graduate students with the opportunity to take part in the grant-writing/review process.

A total of 264 master's and doctoral students have submitted proposals in this competition. One hundred sixteen projects have been awarded. The graduate competition is run exactly like a federal competition. Graduate students who receive awards are asked to serve on a panel to review applications in the following year's competition. This experience provides students with an opportunity to develop their skills in grant-writing and reviewing — skills essential for them in their professional careers.

SEEDS

Small Industry and Matching Grants Competitions

The Matching and Industry Small Grant Competitions are specifically designed to develop partnerships with private industry and non-profit foundations. Industry Small Grants provide up to $6,000 from the SEEDS program while Matching Grants provide up to $50,000. Investigators are required to obtain at least a dollar-for-dollar match from industry for both of these competitions.



Cost-Effective Data Collection Techniques for Characterizing and Managing Variability in Quality and Yield of Grapes in Ohio

Imed Dami, Horticulture and Crop Science
Mohammad R. Ehsani and Barry J. Allred, Food, Agricultural, and Biological Engineering

The wine and grape juice industry are growing in the state of Ohio and are currently valued at more than $70 millon and $10 millon, respectively. Grape growers, like producers of any horticultural crop, are faced with challenges as they attempt to maximize production and thus profitability while producing a uniform product. Growers have long realized that even identical biological factors such as variety, clone, and rootstock in a vineyard produce grapes of varying maturity and wine quality.

Due to the lack of methods and tools that aid in identifying and quantifying variability, uniform management practices continue. However, information technologies and tools — such as global positioning systems (GPS), geographical information systems (GIS), remote sensing, and proximal soil sensing, having proved successful in managing variability in field crops — offer opportunities to acquire detailed geo-referenced information about vineyard performance to identify site-specific management strategies to optimize productivity in terms of both yield and quality.

Assessment of yield variability is usually a first step in precision agriculture studies before contemplating further management action. Therefore, this project was initiated to address three objectives:

- To quantify variability within vineyards.
- To understand underlying causes by analyzing topography, soil, and plant parameters.
- To explore the utility of airborne and proximal (ground-based) remote sensing as means of monitoring variability in vine canopies, both for quantifying variations in yield and quality attributes and for making segregated harvesting decisions.

A collaborator's vineyard was divided into a grid, and yield was collected for each grid section and mapped to have a quantitative assessment of yield variability. In order to understand the cause of yield variability, topographic, soil, and plant data were collected. Soil samples on a fine-scale grid were taken and analyzed along with moisture and electrical conductivity data. Remote sensing data was acquired through aerial imagery. In addition, data from GreenSeeker™ sensor, which is a proximal sensing device, was collected.

All of the data then was analyzed to find relationships between yield and quality. Decisions to divide the fields into two zones based on differences in grape-quality parameters were made and used to implement segregated harvesting with a view to harvesting uniform quality grapes.

A three-fold variation in grape yield in the study area of approximately 1.25 acres was observed, which was surprising for the grower. In general, an inverse relationship was observed between yield and grape quality, measured in terms of parameters such as sugar, pH, and acid content.

The field topography and major and minor nutrients were not found to be yield-limiting factors. Based on statistical regression analysis, clay content, organic matter, and pH were found to be strongly correlated with soil electrical conductivity values. Thus, electrical conductivity of soil can be described to be valuable in delineating within-field variable zones.

Aerial imagery and the GreenSeeker™ sensor provided useful information about crop canopy status and helped explain yield and quality variability without obtaining information on vine parameters across the whole vineyard. The grape quality map created by picking grapes from locations guided by remote sensor information led to the division of fields into high- and low-quality zones. The grapes from the low-quality zone were harvested a week later than the high-quality zone to ensure similar quality.

As the study field was divided into grids, a pattern of yield variation was observed. The high-yielding grids in the study field during the first year returned lower yields in the following year, helping the grower understand the importance of maintaining optimum fruit load on vines. Armed with the quantitative yield data, the grower had more confidence in making management decisions about replacing those vines that performed below expectations.

Continuing the study for a longer duration will help in establishing relationships between grape canopy vigor, yield, and quality parameters. This will enable scientists to study the impact of variable application of inputs *(e.g.,* fertilizer, water, canopy management techniques, canopy training techniques, etc.) on outputs *(i.e.,* grapes and wine) and provide growers with the confidence needed to make changes in their management decisions.

Root Hardiness and Influence of DNA Herbicides in Overwintered Containers

Hannah M. Mathers, Horticulture and Crop Science

Much of the above-ground killing occurring in woody plants is likely the result of root-killing and the destruction of many absorbing organs of the plant. Despite the importance of the root system in determining the northern extent of woody plant survival, relatively little attention has been given to the freeze resistance of roots. For many years, root-killing has been a major form of winter injury and yet one that has often been overlooked. Factors that improve root function and reduce root injury are considered key to improving water, nutrient, and growth efficiencies.

Dormancy does not occur in roots. Mature roots can but do not enter dormancy. The roots of woody plants are capable of growth, at any time. The impact of root-inhibiting herbicides on root and shoot cold hardiness and regrowth after overwintering is of interest to many nursery growers.

The majority of caliper tree production is conducted in northern climates of the United States — the Midwest, Atlantic, and Northeastern states. Selection of cultural practices such as what herbicides do not reduce hardiness is essential to the economic survival of nurseries and landscape operations in these states. Methods that would decrease possible stock losses and delays in plants reaching marketable sizes due to cold injuries would be of significant economic importance to growers, landscapers, and retailers in these regions as would methods to improve landscape tree performance and survival.

Dinitroaniline (DNA) herbicides are often used in nursery containers for weed control. DNA herbicides have many beneficial qualities for use in the nursery industry, including low solubility, little translocation in plant tissues, high adsorptivity, and preemergence activity on many monocots and small-seeded dicots. DNA herbicides as a group are probably the safest herbicides labeled for use on ornamental crops.

Although dinitroaniline herbicides have low water solubilities and are tightly bound to organic matter, their presence in the root zone is still probable. The mode of action of DNA herbicides is through root inhibition. Most plants have "hardiness zones" in which the plant grows and is best adapted; however, there is little information on just how cold tolerant many species of plants are. There is even less information on how herbicides can affect the cold tolerance of plants.

Researchers sought to determine young and mature root hardiness values for containerized plants treated and not treated with DNA herbicides and investigate differences in growth potential between untreated and DNA-herbicide-treated containers 30 and 60 days after emergence from overwintering. It was assumed that roots exposed to DNA herbicides would be negatively affected by the presence of the herbicides in comparison to those not exposed to DNA herbicides.

Two trials were repeated in time to test the effects of DNA herbicides on root cold hardiness over two years. Both trials used the following species — variegated dogwood, Bailey's compact viburnum , Golden barberry, and Magic Carpet spirea. In each trial, five single pot replications of each of the species were treated with 1X label rates of oryzalin, pendimethalin, prodiamine, and trifluralin on four different occasions. The plants were subjected to artificial controlled freezing temperatures of 0°C, -5°C, -10°C, -15°C, and -20°C in an Ultra-low freezer.

After plants were subjected to freezing, they were put into a cooler for 24 hours for thawing. After they were thawed, the plants were potted up into one-gallon containers or destructively harvested to retain a root sample for analysis of cold hardiness of the young and mature roots. Those that were repotted were analyzed for regrowth at 30 and 60 days after freezing. Some of the plants were allowed to stay in the ambient conditions for overwintering and were subjected to analysis for regrowth at 30 and 60 days after emergence during the first and second years of the study.

This research with container-grown plants has been the first to indicate root hardiness is influenced by the common practice of applying DNA preemergent herbicides prior to overwintering. Root injury can result in delayed and retarded growth throughout the growing season and become more susceptible to water stress and disease. The data showed regrowth of stock the following spring and that root hardiness is affected by certain herbicide applications in the fall before overwintering.

The greatest benefit of herbicide treatments occurred in the temperature range of 0°C to -5°C. The species most affected by herbicide were dogwood and viburnum. The best measure of effects was at 30 vs. 60 days. The herbicide effects were also greatest with young roots vs. mature roots.

Fluctuations in temperatures were greater and had a longer duration in the second year. Herbicide treatment effects were greatest when temperature fluctuations were greater during the second year of the study. Evidence indicates the ambient group in the second year of the study did not correlate as well as in the first year with percent survival data of young roots indicating soil temperature fluctuations are a major factor in root survival.

Herbicide effects were greatest with oryzalin and prodiamine. Oryzalin effects were more pronounced during the first year when plants were smaller. The effects were also more pronounced with prodiamine during the second year when starting plants were larger. Data indicates the prodiamine and oryzalin may serve to protect the roots between 0°C to -5°C under fluctuating temperature conditions.

Weed control is the largest expense faced in the nursery and landscape industries. As a result of weed competition, growth and aesthetic value of the crop or landscape plants are reduced. Nursery growers may spend $967 to $2,228 per acre for supplemental hand weeding over and above herbicide application costs. Economic losses due to weed infestations when no herbicides were used have been estimated at approximately $7,000 per acre. Preemergent herbicides are commonly used to reduce these hand-weeding costs and economic losses.

Although the preemergents increase growth, the research showed they also increase the incidence of winter injuries and mortality and reduce regrowth potential. The economic importance of increased growth with herbicide applications with some species may be negated by the increased susceptibility to cold injuries. As a result of this study, industry partners funded a separate study to investigate the influence of several commonly used preemergent herbicides on several species of field-grown trees.

Regulation of the Growth of Turkey Skeletal Muscle

Sandra G.Velleman, Animal Sciences

In Ohio, turkeys aren't just for Thanksgiving anymore. Ohio ranks in the national top 10 in turkey production. While turkey sales in the Buckeye State are on the rise and the poultry industry itself has a total production value of $600 million, there are still some commercial losses that are seriously ruffling some feathers.

The trend of the poultry industry has been to select birds with increased growth rate and muscling. Although growth rate, feed conversion, and muscling have improved in meat-type birds, meat quality has been altered. One example of a meat-quality problem experienced by the turkey-processing industry is a condition similar to the pale, soft, and exudative (PSE) meat found in swine.

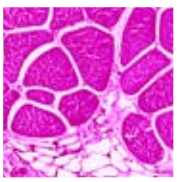
Turkey PSE meat — when cooked — has a soft texture, poor meat binding, poor juiciness due to reduced water-holding capacity, and increased yield losses. According to a recent study, approximately 40 percent of commercial turkey meat exhibits poor water-holding capacity, which represents a significant financial loss to the poultry industry.

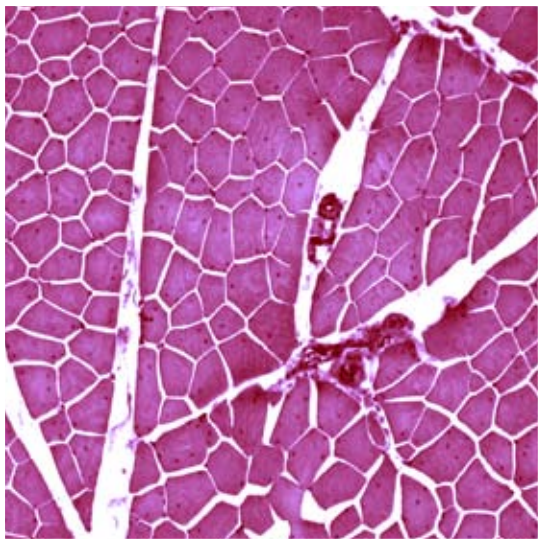
The change in meat quality largely results from a dearth of information concerning the effect of growth selection on the biological mechanism of muscle formation and growth. The goal of this research was to identify gene expression parameters associated with enhanced muscling.

The proliferation and differentiation of muscle cells are regulated by the extrinsic or extracellular environment. The extracellular matrix (ECM) that surrounds muscle cells consists of fibrous protein (collagens) and nonfibrous macromolecules (proteoglycans). The proteoglycans containing heparan sulfate are present on the surface of muscle cells or in the ECM and can interact with a variety of molecules. This interaction affects muscle growth properties including growth factors. Little information is known about how the expression levels of different heparan sulfate proteoglycans may be related to skeletal muscle growth characteristics.

This research examined the expression for four different heparan sulfate proteoglycans in turkey breast muscle in growth-selected and non-growth-selected turkey lines. The results indicated that each of the heparan sulfate proteoglycans had distinct expression patterns suggesting that they may play different roles in the regulation of muscle growth.

Findings from this gene expression research are being used as a basis in current research. The current research project is addressing signaling mechanisms that are likely to be regulated by each of these proteoglycans in the control of muscle growth. This discovery brings the state and national poultry industry one step closer to unlocking the key to optimal muscling gene expression in turkeys.





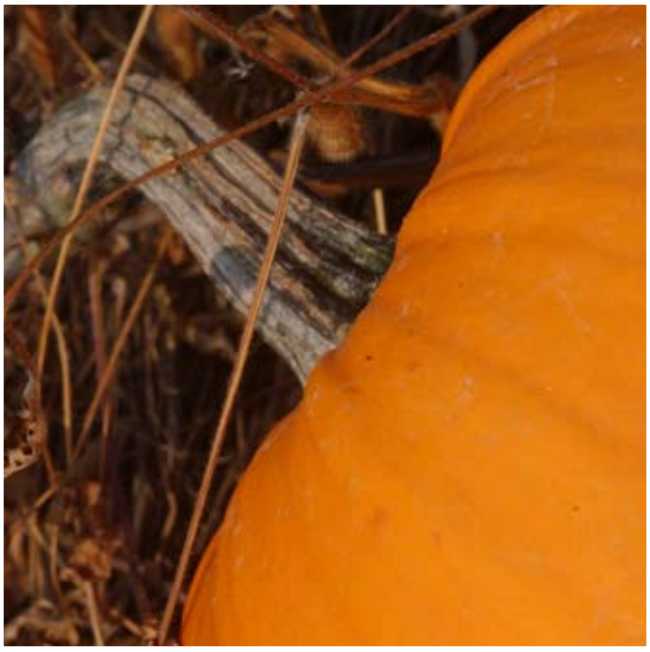
Integrating Powdery Mildew Tolerance and Fungicide Disease Control Programs to Maximize Economic Return for Pumpkin Production

James R. Jasinski, Ohio State University Extension
Robert J. Precheur, Horticulture and Crop Science

Every year certain diseases pose serious threats to pumpkin crops. Some of those diseases include powdery mildew, downy mildew, microdochium blight, and watermelon mosaic virus. Powdery mildew can be controlled by fungicide application but costs may be high and prohibitive. Powdery-mildew-tolerant (PMT) varieties have been introduced to this region, and these varieties can help lower disease costs associated with disease control as well as the amount of fungicide entering the environment. Downy mildew control may require one to several applications of a high-cost fungicide such as strobiluron.

Two pumpkin varieties, Super Herc (PMT) and standard Pro Gold 510, were selected for research and seeded. They were placed into single-row plots in a randomized complete design with four replications. The plot size was 40 feet by 15 feet.

Three different programs were implemented during the study — a low-cost program, a standard program, and an intensive fungicide program. In the low-cost program, spray intervals were seven to 10 days apart. This program utilized both organic and inorganic fungicides to control bacterial and fungal diseases. The standard program utilized only synthetic organic fungicides, including the Strobiluron class, which have laminar systemic activity for enhanced disease control. The standard program was also sprayed on a seven- to 10-day interval. Fruit quality and yield were expected to be higher than the low-cost program. The intensive fungicide program mirrored the standard program but sprayed on a three- to five-day schedule. Fruit quality and yield were expected to be excellent as a result of the most intensive and expensive program.



At the end of the season, foliar evaluations were made to determine the percent severity of foliage infected with powdery mildew, downy mildew, and other prominent diseases. In addition, yield data such as handle quality (the presence or absence of powdery mildew), average fruit weight, number of fruit per acre, tonnage per acre, and fruit disease susceptibility were recorded.

It was noted in this research that fungicide spray programs actually had no effect on pumpkin fruit numbers per acre. Also, fungicide spray programs did affect the percent severity of powdery mildew on the bottom of the pumpkin leaves. The low-cost program had a significantly higher incidence of infection compared to all other treatments, regardless of variety. On the top of the foliage, powdery mildew control was virtually the same among treatments. Only the low cost-Pro Gold combination had significantly more powdery mildew than the intensive-Super Herc and standard-ProGold combinations. The standard fungicide program remains the best recommendation. It was the cheapest in cost and had the lowest environmental impact.

The 2005 growing season was quite dry and very warm. It is important to realize that a wet season with high disease pressure might yield different results. Funding is sought for a second year because a wetter growing season might separate out differences in variety resistance and the disease control program.

Improving the Safety of Ready-to-Eat Egg Products

Sheryl Barringer, Food Science and Technology

Listeria monocytogenes, a bacteria, is a major problem in the ready-to-eat food market because it is a pathogen that is found everywhere. *L. monocytogenes* has been responsible for many food-related illnesses and deaths. Because of this bacteria, the USDA has set a zero tolerance limit for *L. monocytogenes* in foods that will be eaten without cooking or will only be warmed. The objective of this project was to develop a method to produce ready-to-eat cooked egg products that are both safe and tasty.

The first approach was to lower the pH of raw eggs to below the minimum pH needed for growth of *L. monocytogenes.* The food-grade organic acids — citric, sodium acid sulfate, malic, tartaric, and lactic acid — were tested. Citric acid produced a good texture with a pleasant orange flavor. Sodium acid sulfate produced a good texture with a sour off flavor. Malic acid produced a strong off flavor. Tartaric acid produced a slight off flavor with a mushy texture. Lactic acid produced the best results but still had a slight off flavor. Various combinations and masking agents were tested, but ultimately none were successful at covering the off flavors produced at the necessary pH to inhibit growth of *L. monocytogenes.*

The next approach was to develop a cooked, ready-to-eat product that could be distributed frozen and then microwaved without having to be thawed. Various freezing conditions were tested to prevent the formation of package ice from cooling steam. The best combination was to freeze before packaging in a still-air freezer until the center temperature reached 70°C. This resulted in no package ice formation during storage. The process could be shortened by freezing in a blast freezer to an internal temperature of -1°C.

Microwave thawing initially produced uneven temperatures within the food. This was solved by heating the sample for 1 minute 40 seconds while sealed in a bag. To eliminate variations in the food product's texture throughout the product's shelf-life and during the freezing and re-heating process, a cross-linked modified food starch was added to the formulation. This approach produces an acceptable product but is limited to frozen distribution.

Future work will look at the addition of antimicrobials. Antimicrobials can be mixed in with the other ingredients, or applied as a powder to the surface of the product. Surface application has the advantage that less needs to be added, because it is added directly where it is needed. The disadvantage is that the covering must be uniform across the entire surface since microorganisms will grow anywhere the antimicrobial missed.

Future work supported by an industry partner for $14,745 will study the use of electrostatic coating, which has been shown to produce more even coating then regular coating, to apply antimicrobials. If electrostatic coating can produce even, uniform application of antimicrobials, a minimal amount can be added while still producing a safe product.

Vegetable Transplant Production Strategies for Increased Field Establishment, Survival, and Optimum Yields

Mark A. Bennett, Horticulture and Crop Science

Vegetable transplant production can be challenging for greenhouse producers and growers producing their own transplants. Vegetable holding strategies, due to spring weather planting delays, can also be a challenge. Oftentimes these strategies result in poor quality plants, which lead to delayed seedling development, reduction in field establishment/survival, and a reduction in final marketable crop yield.

Tomatoes and cabbage are two commercially grown vegetable crops in Ohio that are established with five- to six-week-old transplants. When a delay in planting occurs, holding transplants for longer than a few days can result in weak stems and poor quality plants. Management practices to extend this holding period without affecting final crop yields may assist growers in storing transplants an additional three to 10 days prior to field transplanting.

Vine crops such as winter squash and melons — produced mainly from transplants in Ohio — only need three to four weeks of greenhouse growth prior to transplanting. However, the root systems of vine crops are often inadequate after three to four weeks to support the vigorous foliage growth. Methods to increase root growth during the brief growth period of the transplants would likely aid in transplant establishment, field survival, and final crop yield.

Tomato and cabbage transplants were seeded into 288-cell plug trays. Plants were hardened off for 0, 3, 5, or 10 days prior to transplanting to the field. Hardening off conditions consisted of placing plug trays on a flat bed wagon under a covered storage building. All treatments were planted in four replications.

Standard pesticide applications were applied throughout the growing season. The tomatoes and cabbage were mechanically harvested. There were no differences in marketable yield, average fruit size, or percent red fruit in tomatoes for any of the holding times prior to transplanting. There were no differences in yield, average head weight, or head measurements for cabbage.

A preliminary greenhouse study using abscisic acid (ABA) on tomatoes for height control was also conducted. Tomatoes were seeded into 200-cell plug trays. After six weeks, ABA was applied at 200 ppm and 400 ppm along with an untreated control. Plants were measured after 12 days, placed under shade cloth, and measured again after five days. Preliminary results

show ABA reduced plant height when applied at both rates of 200 and 400 ppm.

Additional studies are underway to investigate the use of ABA and polyethylene glycol 8000 on processing tomato, fresh market tomato, and fresh market bell pepper transplants for any effect on stand establishment, crop development, and final yield.

'Spin-Out', a copper paint treatment, was applied to the inside of 50-cell plug trays with a sponge brush. Muskmelon and butternut squash were seeded into the flats along with untreated controls and grown in the greenhouse. There were no differences in seed germination in the treated and untreated trays for both crops. Plants were then transplanted to the field. Plants were spaced three feet apart with rows spaced 7.5 feet apart on bare ground. Melons and squash were harvested one month apart.

Copper-treated trays showed a trend for increased yields compared to the untreated control in both the melon and squash. Marketable yields for muskmelon with the copper treatment were 15.3 tons per acre (T/A) compared to 13.6 T/A for the untreated control. Squash marketable yields with the copper treatment were 33.9 T/A compared to 28.8 T/A for the untreated controls. Additional studies will be conducted to confirm these results. Copper trays may be a transplant quality strategy implemented for increased yields.

Increasing the Efficiency of Marker-Assisted Selection through in Silico and Experimental Discovery of Single Nucleotide Polymorphisms

David M. Francis, Horticulture and Crop Science

Ohio ranks third in the United States for the farm value of both fresh-market and processing tomatoes with a combined farm value that exceeds $85 million. The research supported by this grant was intended to bridge a gap in the availability of DNA-based markers for genetic analysis within breeding populations of tomato. The lack of genetic markers that detect differences between elite breeding lines has prevented detailed study of traits of agricultural importance.

Most academic studies in tomato have used wide crosses between weedy relatives and cultivated varieties. This approach maximizes genetic variation and has lead to the discovery of new genes, but it has also left a void in our knowledge of and ability to manipulate many traits of agricultural importance. For this reason, the application of marker-assisted selection (MAS) to tomato improvement is primarily for the introduction of traits from poorly adapted plant material and has not been utilized to more fully compliment traditional plant breeding.

The aim of this study was to develop data-mining techniques that target variable portions of genes and then exploit these regions of variation for genetic mapping of traits important to Ohio growers and processors. The approach leveraged emerging data from genome sequencing projects, laboratory techniques such as those used in forensics for DNA fingerprinting, and created a database to facilitate tomato breeding.

This project, and subsequent work funded by the USDA's National Research Initiative (NRI), identified more than 400 molecular markers for tomato breeding applications. Some 180 of these are currently available in our on-line database at http://tomatomap.net. These markers have been applied to the development of new disease-resistant varieties, and we are currently trying to improve color and color uniformity.

This scientist is currently pursuing even more efficient approaches for the discovery of new genetic markers, genes of agricultural value, and integrating technologies. One such approach uses a gene chip to identify genetic differences. The integration of genetic data and trait data selected is being accomplished in complex populations that are expected to yield new tomato varieties for Ohio growers.

Several candidate genes are being assessed. The results of this assessment will explain variation between lineages relative to environmental adaptation, market class, fruit morphology, color, and nutritional quality. These analyses are laying a solid foundation for linking specific alleles to traits. The work is being supported by USDA in the amount of $157,895.

Liposome Protected Nutrients for Newly Received Feedlot Calves

Francis L. Fluharty and Steven C. Loerch, Animal Sciences

Calf morbidity and mortality associated with bovine respiratory disease is estimated to cost the U.S. beef industry approximately $500 million annually. Onset of respiratory disease results from high stress levels, poor feed intake, and a compromised immune system in calves after arrival at the feedlot. This project investigated a novel approach for delivering nutrients required to support the immune system in an encapsulated form. The goal was to enhance consumption and small intestinal absorption of these nutrients delivered by a capsule.

Ingredients Innovations International Company developed liposome encapsulation methodologies to increase availability and absorption of fat-soluble vitamins, B vitamins, selenium, zinc, and chromium. These are key nutrients that are known to enhance immune-competency.

Two experiments were conducted to evaluate the effectiveness of liposome encapsulated nutrients to improve the health, performance, and humoral immune response of weaned steers, new to the feedlot environment. A third study evaluated the stability of thiamine fortified liposomes during rumen fermentation *in vitro.* Development of liposome formulations to encapsulate vitamins and minerals was successful.

During the first year, providing vitamin and mineral protected liposomes in feed or water did not enhance calf performance, health, or immune competency. It is possible that the animal model used for this experiment was not adequate to test the researchers' theory. The calves used in this trial originated from three Ohio State University farms located in Ohio. Typically, the incidence of morbidity for newly received calves from these sources is close to 25%. However, during the first year, morbidity was only 10%. This low incidence provided a poor model in which to test the theory. Management, nutrition, and background of the calves were similar to previous years.

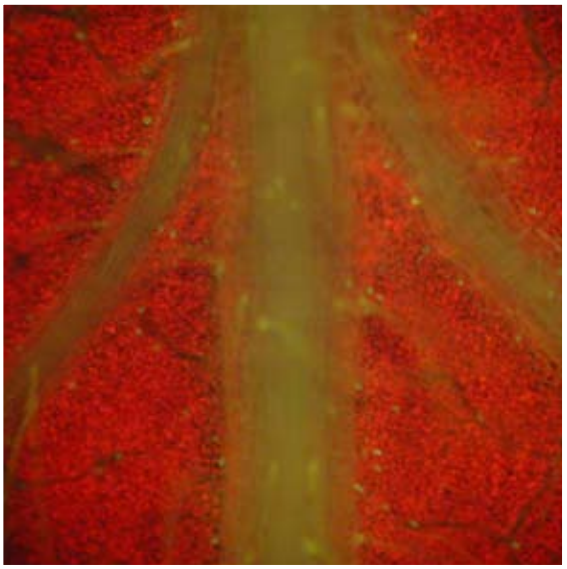
During the second year of the study, morbidity averaged 31.6%. This degree of respiratory disease is ideal for identifying approaches to enhance immune status and reduce disease. Overall growth and feed intake were not affected by source of supplement. However, there were many promising findings that resulted from the use of liposome protected minerals and vitamins.

For newly weaned feedlot calves that are at high risk for respiratory disease, feeding liposome protected minerals and vitamins reduced morbidity and delayed the progression of respiratory disease outbreak. Continued discussion with various industry partners about market opportunities for this specific technology and intellectual property is ongoing.

SEEDS

Interdisciplinary Team Competition

The Interdisciplinary Team Competition is designed to stimulate new collaborative partnerships in multiple departments and colleges or build on existing programs of excellence. Interdisciplinary research provides expertise over several disciplines, bringing a more holistic approach to research questions and problems.



Mechanisms and Outcomes of Host-Mediated Systemic Interactions Between Pathogens and Insects in Austrian Pine over a Nutrient Gradient

Pierluigi (Enrico) Bonello, Plant Pathology
Robert C. Hansen, Food, Agricultural, and Biological Engineering
Daniel A. Herms, Entomology

Nationwide, pines are the fourth largest selling crop in U.S. nurseries with approximately 30 million plants produced annually and a value exceeding $100 million. Once pines achieve ages of 15 to 18 years in the landscape, their value exceeds $200 per tree, for a total estimated value of at least $6 billion. The economic impact of ornamental pests can be dramatic — as the sale of even lightly infested plants is prohibited.

Pines, unfortunately, are afflicted by numerous fungal pathogens and insect pests that often severely limit their ecological, environmental, and commercial value. The development of sustainable management programs for natural, plantation, urban forests, and Christmas tree farms is crucial as fungicide and pesticide use continues to be dramatically restricted by the Food Quality Protection Act. Fundamental to the development of such sustainable management programs is a more comprehensive understanding of the physiological and biochemical processes between trees, pathogens, and insects.

This study focused on Austrian pines; *Sphaeropsis sapinea,* a common fungal pathogen of pines causing Diplodia tip blight and canker; and the European pine sawfly, an important defoliating insect. The system of Austrian pines, *S. sapinea,* and European pine sawfly was chosen as the focus because of their importance in the green industry of Ohio and the Midwest.

The research was driven by the central theory that *S. sapinea* triggers whole plant-level signals in Austrian pine, leading to alterations in the natural defenses that define the resistant or susceptible response to either the pathogen, the insect, or both. Plant-level signals prime the plant to respond to further attack more quickly and more intensely so the whole plant becomes more resistant. Such signals are molecules (unknown at present) that presumably travel in the tree's circulatory system to trigger these enhanced resistance responses. A reciprocal induction of similar responses by the insect was also studied. The whole system was subjected to three levels of soil fertility to test the hypothesis that host defense responses are lowest at the highest fertility due to a reallocation of resources toward growth.

In the course of this project it was discovered that trees infected with *S. sapinea* became more resistant to the same pathogen and even to defoliation by the insect. However, defoliation by the insect did not result in lower susceptibility of the trees to the pathogen. This indicates that *S. sapinea* is recognized by the tree and, in turn, generates molecular signals that prime the tree to respond more forcefully to subsequent attack by either pathogens or insects.

This result is important because it shows that if the signaling molecules can be identified, they could potentially be used to "immunize" trees against at least some pathogens and insects. If this is possible, the need for fungicides and pesticides could

be significantly reduced. Furthermore, if the fungal components that trigger this response are identified, theoretically they could be used as "vaccines."

Scientists also found that several known and novel defense responses were induced by infection with the pathogen at the whole-plant level, and some were correlated with resistance. Soil fertility did not affect these interactions, which suggests that the biological relationships are more important in this system than the amount of nutrients available to the plant.

Additional research is needed to test the hypotheses developed during the course of this project. If the results are favorable, work on refining the methods of introducing the desired responses to disease and insect infestation will be the next step. Using funds in the amount of $382,000 from USDA, we plan to pursue the identification of the signaling molecules involved in the phenomenon of induced resistance and to better characterize the resistance mechanisms/genes that condition this response.

Virulence Mechanisms of *Moraxella Osloensis* to the Slug *Derocerus Reticulatum*

Parwinder S. Grewal and Ronald B. Hammond, Entomology
Srinand Sreevatsan, Food Animal Health Research Program

Slugs *(Mollusca: Gastropoda)* are serious pests in nurseries, home gardens, landscapes, greenhouses, and field crops across the United States, Canada, and Europe. Slugs can completely consume young seedlings and heavily damage mature plant foliage. Although molluscicide baits containing metaldehyde are available on the market, they are generally ineffective, especially under damp conditions.

Out of desperation, some commercial growers will formulate their own baits from carbamate insecticides that are registered for other uses. Both metaldehyde and carbamate insecticides can be toxic to birds and mammals. Mechanical control methods such as barriers or beer baits may help but are laborious and generally not satisfactory. The development of an effective biological product for the control of slug pests will have tremendous benefit to nursery and greenhouse growers and homeowners.

Molluscicidal nematodes, *Phasmarhabditis hermaphrodita,* which carry a pathogenic bacterium *Moraxella osloensis,* possess tremendous potential for the biological control of slugs. Research suggests that nematode pathogenicity to the slug depends on the associated bacterium *Moraxella osolensis.* Juvenile nematodes transmit the bacteria into the shell cavity of the slug where the bacteria produce an endotoxin, killing the slug within three to six days.

Recently, a commercial product, NemaSlug™ containing molluscicidal nematodes has been developed in the U.K. These nematodes are easily mass produced in artificial media. However, batch-to-batch variation of the pathogenicity/virulence affects the quality and field efficacy of the nematodes. Therefore, a more complete understanding of nematode/bacterium pathogenicity/virulence to the slug is needed.

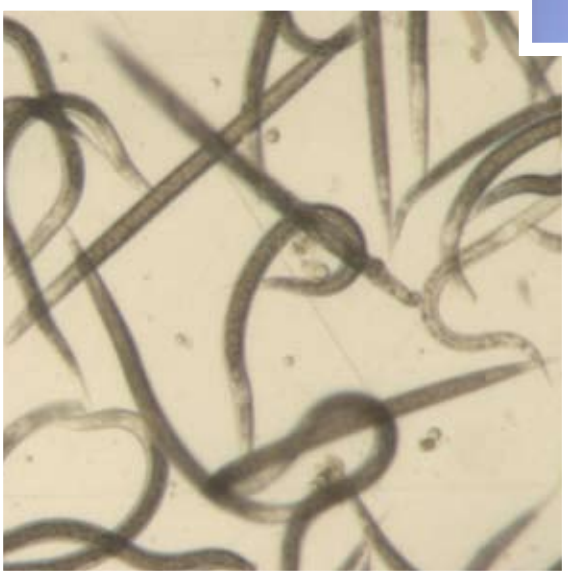
For this project, scientists focused on the molecular mechanisms affecting the virulence of the bacterium to the slugs. Scientists hypothesized that a group of bacterial genes are activated during the infection of *M. osloensis* to the slugs. The specific objectives for this project were to identify and characterize these genes.

To begin, gene expression profiles of *M. osloensis* during slug infection were investigated using a powerful new technique called Selective Capture of Transcribed Sequences (SCOTS). Using this technique, scientists identified 11 bacterial genes that

were activated during slug infection. One of these genes is totally new as it has never been reported from any pathogen ever and thus requires more work.

Using knock-out (mutation) techniques, scientists confirmed three of the other 10 genes to be virulence genes. A gene that encodes for the enzyme ubiquinone synthetase was found to act as a virulence gene in *M. osloensis* in the slug. This gene has not been considered a virulence gene in any pathogen before as it only helps bacteria survive in adverse environmental conditions.

Further research into the functions of the remaining genes is necessary. The preliminary data and information gathered during the course of this project shed light on the significance of the bacterium in this nematode-bacterium parasitic complex, thus pointing to the importance of maintaining the association between the nematodes and the bacterium during commercial production. In the long-term, this information will prove useful in identifying and developing more effective strains of the bacterium to improve the field efficacy of the nematode-bacterium complex against pest slugs.

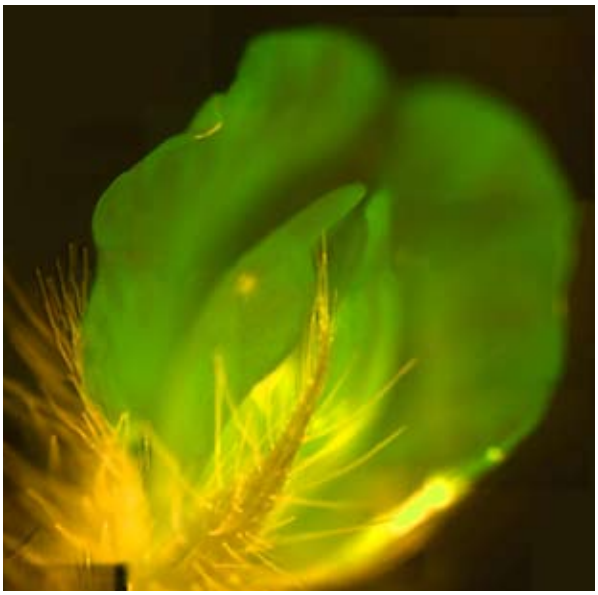


High Throughput Digital Image Analysis for Promoter Analysis in Transiently Transformed Plant Tissues

John J. Finer, Horticulture and Crop Science
Peter P. Ling, Food, Agricultural, and Biological Engineering
Tea Meulia, Molecular and Cellular Imaging Center

In Ohio and across the nation, the percentage of the acreage of corn and soybeans that is genetically modified continues to climb. Approximately 87 percent of soybeans and 35 percent of corn, planted in 2005, was genetically modified. Large efforts are required initially to produce and later introduce genetically modified plants. To produce genetically engineered plants, genes are initially selected that have the potential to show benefit to the farmer, the consumer, and the environment.

The introduced genes are collectively composed of pieces of DNA fragments that are sewn together and evaluated for optimal performance. The optimal performance of genes is first evaluated in the laboratory before attempts are made to incorporate genes into plants for field testing. Evaluation takes the form of checking for reliable and consistent function or expression of new genes in different plant tissues.

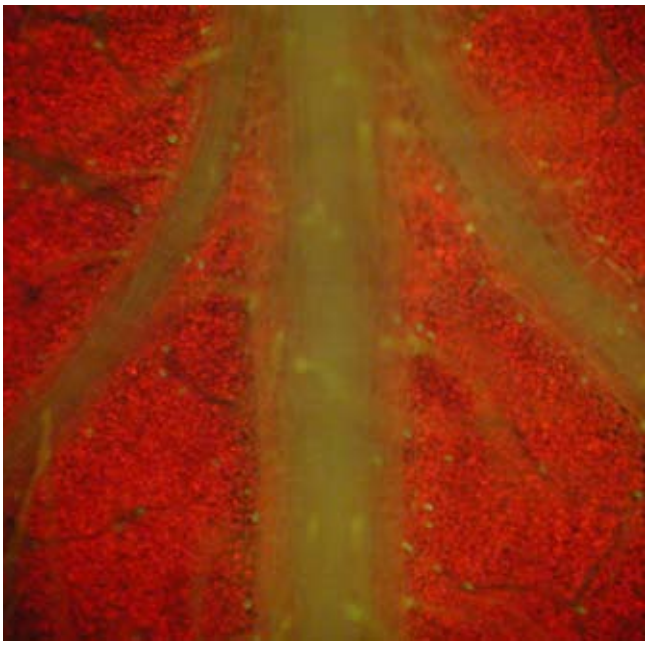


The purpose of this project was to develop and refine a robotic system that would allow scientists to more efficiently evaluate gene components that lead to more predictable and consistent gene expression in genetically engineered plants. This robotic system consists of a two-dimensional robotics table that moves genetically engineered plant tissues in Petri dishes underneath a microscope which, in turn, collects pictures of that tissue for later computer analysis. Analysis of the images allows scientists to compute gene expression levels over time.

Over the course of the project, the interdisciplinary team developed the hardware and software needed to collect digital images of gene expression in plant tissue. Gene expression was visualized using the Green Fluorescent Protein (GFP) gene from jellyfish. Successful introduction of the GFP gene results in a green fluorescent glow in tissues in certain conditions. The intensity of the fluorescence was a direct measure of the strength of gene expression. We optimized conditions for the consistent introduction and detection of GFP. All components of gene introduction were optimized, and numerous parameters for automated image collection were evaluated.

The automated image collection and analysis system that was developed is unlike any other tool. When this work was first started, these scientists were on the front of a technology wave but it was unclear if there was anyone else in the ocean. Today, researchers are still riding the wave, and others are starting to ask the questions that scientists have been able to answer in the past few years.

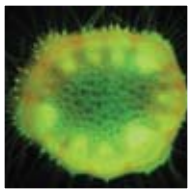
During this research, four different fragments of DNA from soybean were identified as "promoters" — pieces of DNA, in front of the main body of the gene, were identified that determine where and when the gene is turned on. Scientists identified two strong promoters that direct gene expression in all tissues, as well as one root promoter and a promoter that may be turned



on during heat stress. These promoters can now be used to direct the function of other genes in genetically engineered soybean. Prior to this research, less than five promoters had been identified in soybean .

These scientists are also starting to generate hybrid synthetic promoters that take components of different promoters and fuse them together for evaluation. The automated robotics system allows rapid evaluation of the different promoters by following or tracking gene expression in different tissues, over time. Lastly, fragments of DNA that appear to stabilize or normalize gene expression have been characterized. Although the function of these DNA fragments has been suggested, our system will allow us to characterize them in a way not previously available.

Work continues on understanding and refining the technologies discovered during this SEEDS-funded project. This team has submitted an invention report to the Office of Technology Licensing and Commercialization, which is evaluating the patent strategy and seeking commercial partners interested in licensing this new and exciting technology.



SEEDS

International

The purpose of the International Collaboration Competition is to stimulate new collaborations between OARDC and food, agricultural, and environmental sciences faculty and scientists in other countries. Collaborating countries provide laboratory space, equipment transport, and technical support and make other contributions to the project.

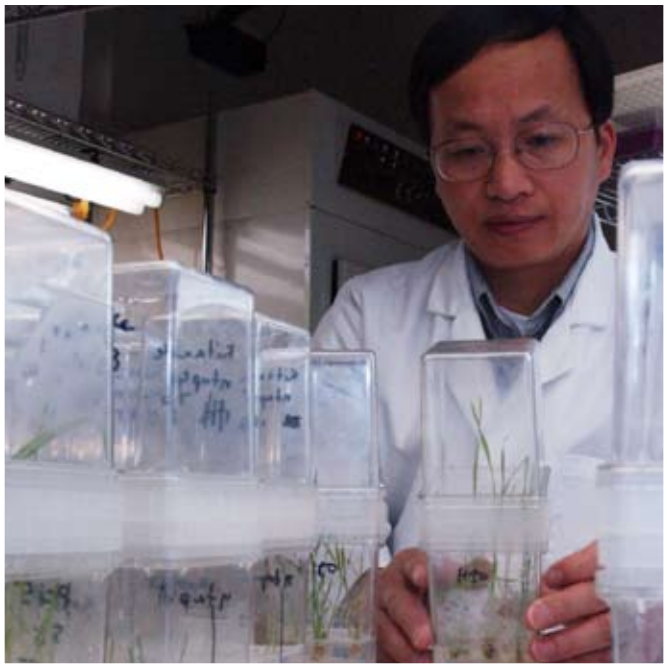
Identification and Mapping of Putative Suppressor Genes of Spl11, a Rice E3 Ubiquitin Ligase Involved in Plant Cell Death and Broad Spectrum Disease Resistance

Guo-Liang Wang, Plant Pathology

Diseases caused by pathogens are one of the major limitations for stable crop production. Frequent application of chemicals for disease control not only significantly reduces farmers' profits but also damages crop ecosystems and the environment in general. Use of genetic disease resistance is a desired approach to effectively reduce yield losses to a minimum level. Elucidation of the molecular basis of host resistance is the essential key to designing novel strategies for breeding new resistant cultivars.

Scientists characterized and cloned a gene that controls the onset of programmed cell death and disease resistance in rice. That specific gene is known as the spl11 gene. Detailed functional analysis of the gene will provide new information on the molecular basis of broad-spectrum resistance in plants since the modified spl11 confers non-race-specific resistance to both fungal and bacterial pathogens. In this international collaboration project, researchers aimed at identifying additional components in the cell death and disease resistance pathways using the mutagenesis approach, which is the creation or formation of a gene mutation. Researchers made significant progress in identifying components in the cell death and disease resistance pathways in the last two years.

Working with the International Rice Research Institute (IRRI), scientists treated the modified spl11 in order to induce point mutations. This specific spl11 mutant was selected because it contains a small deletion at the Spl11 locus that was easily detected by Restriction Fragment Length Polymorphism (RFLP) analysis, a very popular method used in genetic footprint testing. During the summer, scientists screened more than 7,500 lines for lesion suppression phenotype at IRRI. Two categories of suppressor mutants were identified: type A and type B suppressors. Both categories showed total and partial lesion suppression.

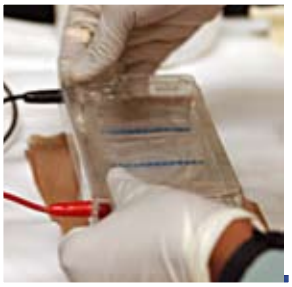


Genotyping — or characterizing by genetic make-up — revealed that all except one of the type A suppressors were either heterozygotes (possessing two forms of a particular gene encoding) for the spl11 or wild type contaminants, while all type B suppressors and one type A suppressor were homozygotes (possessing two identical genes) for the spl11 gene. Phenotyping — characterizing by visible traits — and genotyping confirmed one type A suppressor line and six type B suppressor lines with delayed lesion formation phenotypes. The degree by which lesion formation is reduced and expressed in different plant parts (e.g., more on the outer covering than the leaves themselves or similarly expressed on both the covering and the leaves) varied among the type B suppressors.

In order to determine if the confirmed spl11 suppressors had any disease resistance phenotype, the seven genes identified were inoculated with Philippine Xoo isolate Pxo99, which is a very specific pathogen. It was speculated that the reduced lesion mimic phenotype of the spl11 suppressor mutants might correlate with loss of enhanced disease resistance. Inoculation shows that the spl11 suppressors are as susceptible to bacterial blight as the wild type, confirming that disease resistance is suppressed in these genes.

The selected spl11 suppressors are currently being grown in the greenhouse at both Ohio State University and IRRI in order to make crosses to generate mapping populations. Suppressors at IRRI will be crossed with cultivar Azucena, which has been used extensively for other mapping projects due to availability of a good genetic linkage map. At Ohio State, suppressors will be crossed with an spl11 in the cultivar which will allow for rapid mapping by bulk segregant analysis.

Future planned research involves mapping the genes in at least four repressors. If markers tightly linked to the target genes are found, researchers will start to clone the genes using a map-based cloning strategy. Cloning of these genes will shed light on the genetic mechanism of cell death suppression in plants. Funding is currently being sought to conduct further research in this specific area of genetics.



Comparative Pathogenomics of Epidemiologically and Genetically Diverse Strains of *Mycobacterium avium* subspecies *paratuberculosis*

Srinand Sreevatsan, Food Animal Health Research Program

Johne's disease (JD) is a chronic intestinal disease of ruminants, including domestic and wild species, caused by *Mycobacterium avium* subspecies *paratuberculosis* (MAP). It has been estimated that at least 40 percent of herds in the United States with more than 300 animals per herd are infected. JD has also been predicted to impose an economic burden of $1.5 billion annually to the U.S. agricultural industry. Furthermore, JD has been implicated as a possible etiological agent of Crohn's disease (CD) in humans. Despite considerable research efforts, prevention and control strategies of JD remain a distant task.

MAP persistently infects and survives within host cells called macrophages. Currently, there are no reports on the behavior of diverse clinical isolates of *M. paratuberculosis* within a host/host cell (macrophage). Scientists believe that this critical piece of evidence is important to understanding the complex mechanisms underlying the virulence of this economically important animal pathogen.

We studied comparative gene expression of clinical isolates of MAP in a bovine monocyte-derived macrophage (MDM) environment. Selective capture of transcribed sequences (SCOTS) was employed to identify the genes expressed by a MAP strain (MAP6) isolated from a Crohn's disease patient. cDNA libraries were created from macrophages exposed to MAP.

Results suggest that the bovine and the human MAP isolates lead to anti-inflammatory and anti-invasive pathways in the macrophage environment whereas, in sheep, the MAP leads to a more pro-inflammatory pathway. Thus, the infecting strain genotype may play a role in polarizing the host immune responses and dictate the outcomes in this economically important disease.

The data collected for this study enabled scientists to write a successful proposal to USDA for $350,000 to study genotype-specific host pathogen interactions. These studies will significantly increase our understanding of the early molecular events involved in the pathogenesis of JD, enabling scientists to design intervention strategies such as vaccines and early diagnostic tests.

SEEDS

New Enterprise

The new Enterprise Competition is designed to support the exploration of new enterprises and the elimination of barriers that constrain existing ones. New enterprises are considered to be crops, animals, products, goods, and services that currently are not produed for biological, physical, cultural, processing, economic, or social reasons. New Enterprise projects are funded up to $50,000.

Enhancing the Value of Distillers Dried Grains with Solubles as a Non-Ruminant Feedstuff

Donald C. Mahan, Animal Sciences

As energy prices soar, particularly gasoline, the costs to consumers are expected to continue to climb. With increasing interest in energy costs, lower cost ethanol production is expanding. Ethanol is the product of fermentation made from corn and other grains that can be used as an alternative source of fuel for automobiles and other gas-powered engines, potentially reducing U.S. reliance on foreign oil. Ethanol from corn results in large quantities of a by-product called distillers dried grains with solubles (DDGS). This research focused on expanding the use of DDGS as a high-quality animal food by examining the current quality of existing products and looking at improving its value.

DDGS has a high crude protein (27%) and fiber (40%) content, making it a good feed source — for ruminants. Although DDGS has been used effectively in the diets of dairy and beef cattle, its use in the swine and poultry industries has been limited due to its high fiber content. The intestinal tract of nonruminants cannot effectively digest large quantities of fiber, thus lowering its value for these species. If ethanol production increases at the current pace, it won't be long before the quantity of DDGS being produced will outgrow that needed for ruminant diets.

Scientists now believe that DDGS can be altered to be more easily digested by swine and poultry. Enhancing the digestibility of protein *(i.e.,* amino acids) and improving its energy utilization for swine and poultry has been the goal of OARDC scientists. With such modifications, this will allow ethanol plants to be more profitable simply by increasing the use and sale of this by-product.

The first part of this study involved evaluating the current status of DDGS quality. DDGS samples were collected for analysis from several plants in the Midwest and then evaluated in animal trials. It was found that the qualities of the DDGS

test samples were found to be inconsistent from the various manufacturers. The more critical aspect that influences quality was found to be the drying temperatures of the wet fermented by-product. Drying distiller's grain by controlling the drying temperatures is now recognized as a critical component in regulating quality-control issues.

Results were consistent with the observation that the color of DDGS was considered a good indicator of quality, with lighter-colored products generally being of better quality. Manufacturers oftentimes apply excessive heat in an attempt to quickly complete the drying process, having a negative effect on quality. Samples with lighter color were shown to have a superior amino acid digestibility than darker-colored DDGS.

In the second part of this study, the use of enzymes and acids in an attempt to increase the digestibility of the fiber component of DDGS was investigated. It was found that treating DDGS with enzymes and acids modified the end results, making the fiber fraction more digestible when added to swine and poultry diets. It appears that much of the fiber component in DDGS can be broken down by these treatments, but the best results occurred when a combination of enzymes and acids were used prior to the product being dried. The energy content of treated DDGS was subsequently evaluated in grower pigs and later in adult roosters.

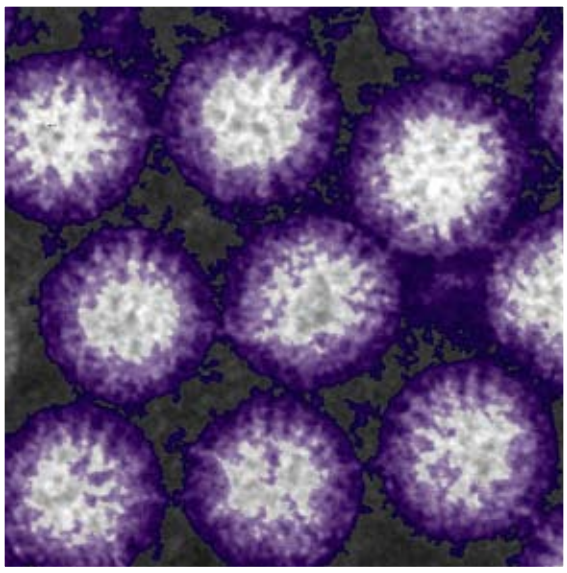
Soaking DDGS in water *(i.e.,* steeping) with added enzymes increased digestibility. Energy digestibility was higher in pigs when the mixture contained supplemental enzymes. These results demonstrate that enzyme supplementation increased both the energy and amino acid digestibility and thus improved the quality and value of the product.

Improved growth rates and feed consumption were subsequently demonstrated in growing pigs when fed the modified DDGS product. The combination of steeping DGGS with the enzymes was clearly better than simply adding the enzymes to dried DGGS. Again, results indicate that if the techniques of using enzymes and acids to treat DDGS are further refined and adopted by the industry, DDGS could be more effectively utilized by all major livestock and pet species.

The processes that we investigated have the potential of increasing the value of DDGS and other feedstuffs normally devoid in swine and poultry diets because of poor digestibility *(e.g.,* alfalfa meal, brewers' grains, coconut meal, corn gluten feed, cottonseed meal, rice bran, safflower meal, sugar beet pulp, sunflower meal, and wheat bran). Therefore, pre-digesting these feedstuffs prior to their consumption by the nonruminant animal may be a more efficient method of improving the utilization of feedstuffs. Findings resulting from this study will be used as fundamental concepts for future research.

Seed

The Seed Grant Competition is designed to encourage new and innovative research and to generate the preliminary data needed for successful application to competitive extramural funding sources. Seed Grants were supported at $25,000; however, in 2004 the maximum funding level became $50,000.



Role of Vitamin C Transporters in Vitamin C Depletion During Regression of the Ovine *Corpus Luteum*

Joseph S. Ottobre and Macdonald Wick, Animal Sciences

One of the major limitations in livestock production is poor fertility. Improvements in reproductive success could greatly enhance the overall efficiency of animal production. Improvements in production efficiency would likely result in increased profits for animal producers and lower costs for consumers of animal products. As researchers of reproduction in animals, animal scientists are continually trying to learn more about reproductive biology in an effort to improve the ability to control and improve reproductive efficiency. The current research was designed to examine some aspects relative to the control of the function of the *corpus luteum.*

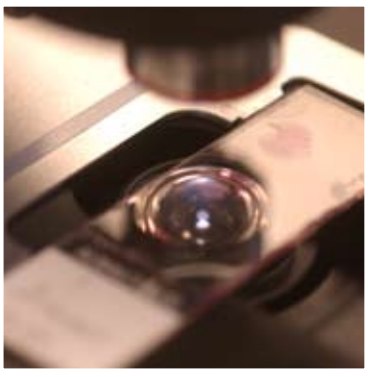
The *corpus luteum* (CL) is a transient structure that forms on the ovary following ovulation. It produces the hormone progesterone, which is required to maintain pregnancy. If pregnancy does not occur, the CL regresses. Prostaglandin (PG) F_2 triggers regression of the CL. Vitamin C, present in extremely high quantities in the functional CL, neutralizes oxygen radicals that would otherwise damage cellular constituents. Thus, vitamin C may play a protective antioxidant role in the CL. Secretion of vitamin C from the CL is one of the first events that occurs prior to regression of the CL. Prostaglandin F_2 causes vitamin C depletion in CL from the early and mid-luteal phase, but only leads to regression in the mid-late luteal phase, not the early luteal phase.

Two sodium dependent vitamin C transporters (SVCT1 and 2) have been described in various species, and the amino acid structures of these proteins are known *(e.g.,* human, pig, guinea pig, rats, mice). The amino structures for SVCT1 and 2 have not yet been reported in sheep. Vitamin C transporters are highly conserved, and it is likely that the sheep CL expresses similar transport proteins.

The first objective for this project was to determine if the pattern of luteal vitamin C secretion in response to PGF_2 is different in the early vs. mid-luteal phase. The second objective was to determine if PGF_2-induced depletion of luteal vitamin C recovers in the early, but not late, CL. In addition, since vitamin C transport proteins would represent critical elements in the regulation of vitamin C concentrations in the CL, another objective of the current work was to determine the primary amino acid sequences for SVCT1 and 2 in sheep.

Four groups of four or five ewes that had at least two CL present were used. Two groups underwent surgery on either day three or 10 of the estrous cycle. One group on each day was treated with PGF_2, while the other group received only saline. Ovarian venous blood samples were taken every 15 minutes for two hours to assess luteal secretion of vitamin C. One CL was removed at the end of the sampling period and another 24 hours later.

Separate studies were done to characterize the structure of vitamin C transporters in the sheep. To do this, the scientists used CL that were surgically collected from regularly cycling sheep on day three of the estrous cycle. Luteal tissue was immediately snap frozen in liquid nitrogen. Using specific primers designed based on known sequences in other species, the scientists were able to amplify portions of the messenger RNA of the sheep transporters. The researchers used DNA sequence analyses to determine the structure of the fragments that were obtained.



The researchers found that treatment of sheep with PGF_2 causes a rapid (within two hours) and substantial depletion of vitamin C from *corpora lutea.* When PGF_2 is administered late in the estrous cycle, a time when the CL is sensitive to the regressing effects of PGF_2, the CL is unable to recover pre-treatment concentrations of vitamin C; however, when PGF_2 is administered early in the estrous cycle, a time when the CL is insensitive to the regressing effects of PGF_2, the CL recovers pre-treatment concentrations of vitamin C. Thus, the recovery of vitamin C concentrations is associated with continued luteal function. Similarly, the lack of recovery of vitamin C concentrations is associated with the regression of the *corpus luteum.* These observations are consistent with a role for vitamin C in the protection of the *corpus luteum* from regression.

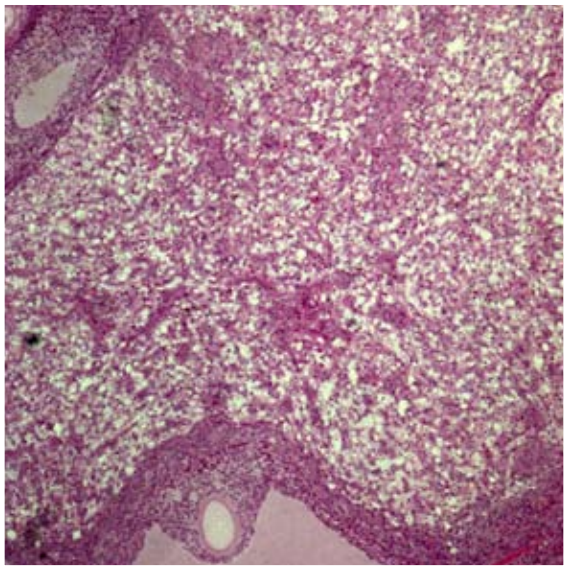
The researchers did not observe an acute effect of PGF_2 on plasma concentrations of vitamin C in veins draining the luteal ovary. This observation should not be interpreted to mean that PGF_2 failed to induce luteal release of vitamin C. Perhaps the current methods lacked the sensitivity to pick up a biologically important change.

The researchers have sequenced a 296 base pair portion of the message for sheep SVCT1 and an 1860 base pair portion of the message for sheep SVCT2. These encode for 98 amino acids for sheep SVCT1 and 618 amino acids for sheep SVCT2. The length of the sheep SVCT1 amino acid sequence corresponds to 14 percent of the presumptive sequence based upon that of the human.

The scientists have found the sheep message for SVCT1 to have high homology (structural similarities between organisms) with that of the human (93 percent), the pig (92 percent) , the rat (90 percent), and the mouse (90 percent). The protein sequence was also found to have high homology with that of the human (100 percent) , the pig (98 percent), the rat (100 percent), and the mouse (98 percent).

The length of the sheep SVCT2 amino acid sequence corresponds to 95 percent of the presumptive sequence based upon that of the human. The scientists have found the sheep message to have high homology with that of the human (90 percent), the pig (93 percent), the rat (87 percent), and the mouse (87 percent). The protein sequence was also found to have high homology with that of the human (89 percent), the pig (88 percent), the rat (86 percent), and the mouse (86 percent).

These findings are vital to further studies of the regulation of SVCT proteins and vitamin C concentrations in the CL of the sheep.



Impact of Gene 5 Sequence Rearrangements on Growth, Virulence, and Pathogenesis of Rotavirus

Lijuan Yuan and Linda J. Saif, Food Animal Health Research Program

Rotaviruses are the leading cause of diarrhea disease in the young of a wide range of avian and mammalian species, including humans. Group A rotaviruses cause more than 600,000 deaths in infants and young children annually worldwide. Human rotavirus oral vaccines — such as the RotaShield (withdrawn from the U.S. market in 1999 due to association with rare cases of a severe side effect) and the recently licensed Merck vaccine RotaTeq (in the United States, Canada, European Union, and Mexico) and GlaxoSmithKline vaccine Rotarix (in more than 70 countries) — have been developed based on using attenuated strains of rotaviruses. These attenuated strains were acquired by reassortment between animal and human rotavirus strains or by extensive passages in cell culture; however, the molecular mechanisms of attenuation of these vaccine strains have not been understood. Studies are needed to elucidate the mechanisms of rotavirus attenuation to facilitate the development of safe and more effective rotavirus vaccines.

Based on previous observations and molecular studies of rotavirus strains with aberrant gene 5 dsRNA, it was theorized that changes in gene 5 (encoding non-structural protein [NSP] 1) may decrease the virulence of rotavirus but maintain or even increase its replication capability in the host, therefore raising the possibility that variants with aberrant gene 5 may prove useful as attenuated rotavirus vaccines. If the theories are proved correct through research, findings from this study could lead to a novel approach for attenuating virulent field rotavirus strains to use them as vaccines for the prevention of rotavirus disease in humans and animals.

To test the theory, researchers conducted experiments using the gnotobiotic (germ-free) pig model of human rotavirus (HRV) infection and disease to do two things. The first was to determine the infection capacity, growth rate, virulence, pathogenicity, and stability of a Wa strain HRV variant with gene 5 rearrangement (Wag5re). The second objective was to determine the molecular phylogenetic relationship of gene 5 between Wag5re variant and its parent strain Wag5wt by sequence analysis.

The major findings from this study are that although the Wag5re is able to infect neonatal gnotobiotic pigs, its infectivity is similar or lower than the gene 5 wild type tissue-culture adapted Wa HRV (Wag5wt) as measured by fecal and nasal virus shedding, viremia, and seroconversion. Virulence of the Wag5re is further reduced compared to the Wag5wt in gnotobiotic pigs as measured by diarrhea rate and mean cumulative diarrhea scores.

No infectious virus was detected in the intestinal contents in the Wag5re or Wag5wt group, indicating a very low rate of virus replication in the intestine. The immunogenicity of Wag5re was lower than the Wag5wt as measured by IgM antibody titers on PID8 in the serum and intestinal contents. The stability of the genome of the Wag5re in the gnotobiotic pigs could not be determined due to the low amount of virus shed by the Wag5re and Wag5wt infected pigs, which is consistent with the lack of infectious virus detected in the intestinal contents, indicative of poor replication capacity.

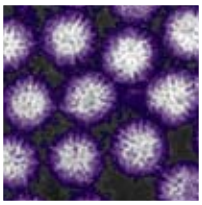
The results suggest that the theory that changes in gene 5 may decrease the virulence of the virus but maintain or even increase its replication capability in the host — raising the possibility that variants with gene 5 rearrangements may prove useful as rotavirus vaccines — was correct for the first part about the decreased virulence. However, the theory was incorrect for the second part about maintaining or even increasing its replication capability in the host. Thus, the Wag5re variant is not promising for use as a rotavirus vaccine due to poor immune response (IgM antibody) induced.

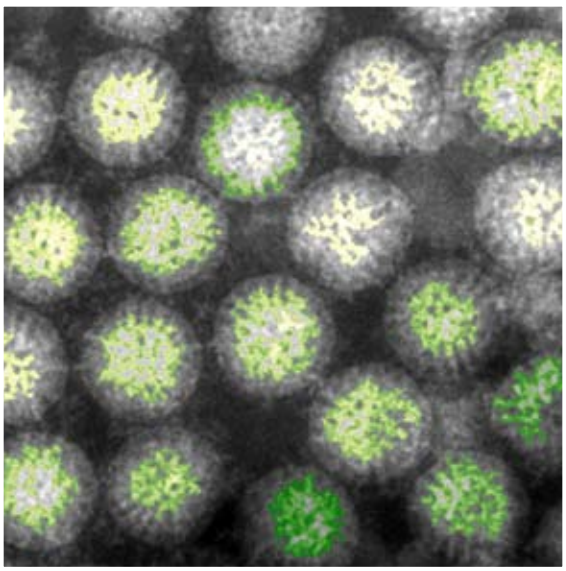
While the Wag5re variant did not prove to be effective for use as a rotavirus vaccine, other findings were of particular interest to scientists. During the process of generating the Wag5re, in parallel with the serial passages of the Wag5wt in MA104 cells, researchers were also serially passaging another Wag5re variant in cell culture. Scientists noticed that in addition to the 5th gene, the 7th gene (encodes NSP3) had started rearranging at around the 40-42 passage level.

Upon further passages of this mixed population, it was also apparent that at around passage 51 (which is the highest passage level analyzed by PAGE thus far), the 11th gene (encodes NSP5 and NSP6) appeared to start rearranging. Another Wa variant with rearranged genes 7 and 8 (Wag7/8re) was derived recently from the attenuated Wa HRV around 33 passages in MA104 cells. The genome sequences of the gene rearranged variants Wag5re and Wag7/8re and the parent strain Wag5wt and the virulent Wa HRV have been completed.

It is interesting and important to examine these Wa viruses with various rearranged genes in the future in gnotobiotic piglets and to analyze various possible *in vivo* phenotypes carried by such viruses, including an "attenuation" phenotype. If "attenuation" can be achieved by introducing certain rearranged gene(s) into the virulent wild-type viruses (although the impact of the rearranged 5th gene in reduced virulence but of sufficient infectivity for a vaccine strain was lacking in this study), it may reveal interesting and practical ways to generate safe and effective candidate rotavirus vaccines. It is noteworthy that once rearranged, such gene(s) of a rotavirus are surprisingly stable as determined by serial passages *in vitro* at high multiplicity of infection.

There are many interesting phenomena observed by researchers during these serial passages of various rotavirus strains *in vitro* that may be important to be analyzed molecularly. In addition, it is also important to analyze rotaviruses with various rearranged genes in an animal model to confirm their *in vivo* phenotypes and infectivity. Future research in this area to further investigate these phenomena is already underway.





Effects of Food Matrix on Bioavailability of Soy Isoflavones

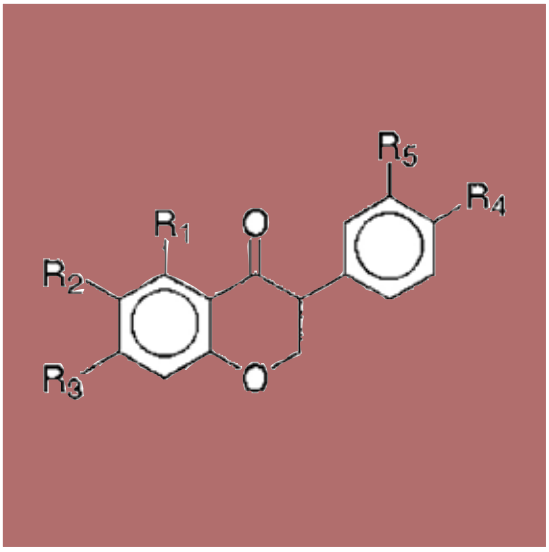
Yael Vodovotz and Steven J. Schwartz, Food Science and Technology

Coronary heart disease is the leading cause of death in the United States; it afflicts as many as 12.9 million Americans and annually contributes to $129 billion in hospital costs. Ethnic and migrant studies indicate that a diet rich in soy foods such as tofu, soy nuts, and soy milk can reduce the risk of diseases common in the United States. Studies have suggested that eating foods with proteins and isoflavones (naturally occurring plant chemicals) that are commonly found in soybeans can reduce the risk of heart disease by lowering cholesterol and improving anti-oxidant levels in the blood.

In spite of the popularity and efforts invested in soy research, information is lacking on how the body uses and breaks down isoflavones. Because there are many factors that influence how the body benefits from soy foods, there is still much dispute in this area. One possibility may be related to differences in the way the soy is consumed. Specifically, a liquid soy drink may be very different than a solid food such as bread. The differences in their texture (matrix) may be important in influencing how the body uses and breaks down soy foods.

To try to understand the matrix effect in soy absorption, a clinical trial was conducted. Twenty healthy adults (10 women and 10 men) with total cholesterol levels between 200 mg/dl and 275 mg/dl (normal cholesterol is less than 200 mg/dl) were asked to take part in a study that involved eating two different soy foods (soy bread and soy shakes). The levels of the protein and naturally occurring plant chemicals found in soybeans were equal in the types of food. Each participant ate one of the two soy foods for three weeks then ate the other type of soy food for three weeks. Blood and urine were collected and studied for isoflavones (naturally occurring chemicals in soybeans).

Information obtained from personal interviews demonstrated that both the shake and the bread were well accepted by the participants. Both foods had good compliance with the



suggested study diet. Participants enjoyed the shake for the convenience at the same time the bread kept many participants feeling full for most of their day. The data collected from the urine samples after each of the soy foods was eaten showed that the metabolites (natural breakdown products from food) of natural soy plant chemicals were being excreted similarly. Furthermore, participants experienced a lowering of their total cholesterol and their triglycerides (a common form of fat that exists in the body) during their six-week participation.

This was the first in-depth study of soy metabolism focused on different soy food consistencies; therefore, we expect to significantly increase the available knowledge about soy breakdown and its use in the human body. Future work will involve more detailed analysis of the different metabolic chemicals and their relationship with different individuals. Additionally, the differences in each individual's metabolic excretion pattern may lead to further clues in the benefits of soy that have not yet been investigated.

Development of Molecular Markers Specific to Biocontrol Strains of *Bacillus subtilis*

Brian McSpadden Gardener, Department of Plant Pathology

The yield and profitability of grain crops can be significantly reduced by soilborne plant diseases. The pathogens that cause seedling diseases of soybeans, corn, and wheat are widespread in soils, and they represent a significant constraint to production world-wide.

Soil and climatic conditions throughout Ohio are generally conducive to soilborne plant diseases, and farmers must carefully manage these diseases to remain profitable. In fact, losses to soilborne plant diseases are estimated to be in the tens of millions of dollars annually in Ohio. Yield losses on individual farms may range from approximately 5 percent to more than 50 percent, depending on the prevailing environmental conditions.

The pathogens that cause these losses may be partially controlled by good cultural practices, but chemical and biological seed treatments can still significantly increase crop stand, seedling vigor, and, ultimately, yield and profitability.

Beneficial microbes with the capacity to colonize roots and suppress plant pathogens inhabit all agricultural soils and may act to limit the incidence and severity of root diseases. By isolating and applying these beneficial bacteria directly to seed before planting, farmers can increase the level of protection afforded by these microorganisms, thereby reducing root damage and increasing vigor of the crop. Because of their reduced toxicity and their potential to provide increased protection, biological seed treatments have long been considered a desirable alternative to chemicals for suppressing plant diseases in various crops. While many biopesticide products are currently available, few are labeled for use as seed treatments. Therefore, our laboratory seeks to identify and develop novel, safe, and cost-effective bacterial inoculants that can be used to protect and increase the profitability of Ohio's major field crops.

One group of beneficial bacteria belongs to the species *Bacillus subtilis*. Several strains of *B. subtilis* have been shown to be effective biological control agents for various plant diseases, and a few have been registered recently for sale as biological fungicides in the United States and throughout the world. Despite their commercial availability, relatively little is known about the molecular basis for disease suppression by *Bacillus subtilis*.

In this study, several genetic markers associated with beneficial activities of *B. subtilis* inoculant strains were identified using a comparative genomics approach. The molecular markers identified in this study were found in occur in several strains of *B. subtilis* used commercially as biofungicides. Additionally, three newly-discovered strains that contained these markers were generally more effective at inhibiting the growth of plant pathogens *(i.e., Rhizoctonia solani* and *Pythium ultimum)* than other *Bacillus* isolates that lacked the markers. Thus, these markers can be used to identify new isolates with good biocontrol activity on different crops. Additionally, these genetic markers can be used to further define the diversity, ecology, and biocontrol activities of *B. subtilis*.

A Proteomic Analysis of the Virulence Targets of the Type III Effectors AvrRpm1 and AvrB

David Mackey, Horticulture and Crop Science

In the United States, Ohio is third in tomato production for processing and fresh market, with annual values of $89 million. It is estimated that Ohio tomato growers lose 10 percent of their annual yield to bacterial pathogens (including bacterial speck). Because tomatoes cultivated in Ohio are not resistant to bacterial pathogens, growers rely on frequent applications of copper.

Negative environmental consequences of copper sprays include toxicity to earth worms and detrimental effects on water quality. Also, an inability to forecast bacterial infections leads to applications of both copper and fungicides made on a schedule rather than as needed. Under such regimens, growers do not take advantage of disease forecasting tools that would permit a reduction of treatments for fungal pathogens. Thus, susceptibility of tomatoes to bacterial infection adds both production and environmental costs that exceed those of yield and quality.

This research focused on *Pseudomaonas* bacteria, which cause many plant diseases, including bacterial speck of tomato. Pathogenicity often depends on the delivery of virulence proteins into the cells of the host. Paradoxically, these virulence proteins are also a primary determinate of resistance (R) protein mediated defense responses in the host. Innate immune responses also occur in animals. In some cases, innate responses are sufficient for resistance. More often, innate responses are critical to activation of the adaptive response. The types of proteins that function in the innate immune system of plants and animals are structurally similar and may, in fact, be evolutionarily related. Thus, study of innate immunity in plants will also improve understanding of immune function in animals.

A central goal of this project was to study how targeting of a host protein relates to resistance responses against virulence proteins. Scientists studied two pairs of secreted virulence proteins and the R-proteins they are known to activate. In common, these virulence proteins target the same host protein that is involved in the function of each of the respective R-proteins. Researchers have discovered that targeting of this host protein causes each virulence protein to weakly activate the R-protein normally activated by the other. Thus, researchers have shown a previously unknown cross-specificity between virulence proteins and R-proteins. The identification of this phenomenon puts us in a strong position to study the molecular mechanism underlying activation of these two R-proteins.

Determining how plants recognize pathogens is a first step towards improving plants used by humans *(e.g.*, crops). The genetics of interactions can guide traditional efforts by breeders. Understanding the molecular mechanisms will permit non-breeding efforts, such as transgenic plants with altered disease-resistance traits or production of chemicals that affect interactions between pathogen and plant proteins.

Additional work is needed, and these scientists have applied to the National Science Foundation to continue their efforts. Results from this work may translate to tomatoes, which would be of great importance to Ohio growers. It is worth emphasizing that the greatest impacts of this work likely will go beyond tomatoes because this effort addresses very basic questions that are fundamental to understanding the interaction between a variety of parasites and their hosts (both plant and human).

Rural Retailers: Profiling Internet Users and Non-Users

Leslie Stoel, Consumer and Textile Sciences

A recent report on digital Internet access suggests that the United States has moved from a digital divide to a speed divide, with a disproportionate share of rural areas not having access to high-speed Internet service. For example, statistics show that 56 percent of cities larger than 100,000 citizens have DSL Internet service, as compared to less than 5 percent of cities with fewer than 10,000 citizens. With 48 of 88 Ohio counties classified as rural, Ohio may be experiencing a speed divide.

It has been suggested that to obtain high-speed access, small rural communities must build demand. To do so, these communities need to upgrade existing businesses through education and assistance. To create effective programs, however, community leaders and public policy makers need to understand the barriers that prevent rural businesses from using the Internet. Retailers, in particular, are an important business to target because they are present in almost every community, are often major employers in rural economies, and play an important role as gatekeepers of social information in the community.

Research on technology acceptance suggests that many of these barriers are personal beliefs of business owners about the technology or their business. Therefore, a study to illuminate retailer beliefs about the Internet would be helpful for community leaders and public policy makers. Internet users will be compared to non-users and beliefs to be examined include attitude towards using the Internet, attitude towards business growth, perceptions of ease of use and usefulness of the Internet, motivation to comply with important others, and perceived control of time. In addition, the county in which the retailer is located and the availability of high-speed access may also cause variance in differences and will be examined as well.

A total of 2,337 surveys were mailed, and responses were received from 210 stores, giving a response rate of 9 percent. Due to significant missing data, 29 responses were deleted from the dataset, leaving 181 responses for analysis. Logistic regression was used to test for differences between Internet users and non-users. Results show that for stores using the Internet for their business, as compared to those not using the Internet, the odds of the store having high-speed access increase by a factor of almost 34.

The analysis also shows that for stores using the Internet for their business, as compared to those not using the Internet, the odds of the store wanting to grow its business decreases by a factor of about one-fifth of one percent.

The results also show that for stores using the Internet for their business, as compared to those not using the Internet, the odds of the store having a favorable attitude towards the Internet almost triple.

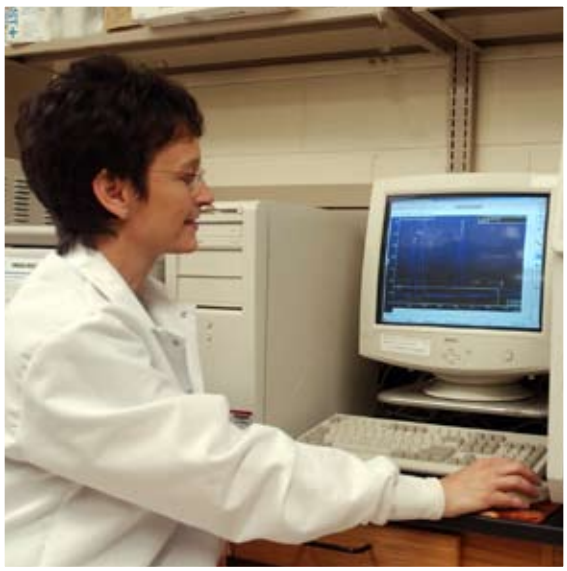
Beliefs about ease of use and usefulness of the Internet, perceived control of time, motivation to comply with important referents, and the retail economy of the respondent were not significant predictors of use of the Internet for the business. Interaction between high-speed access and retail economy were also not significant.

Results show that businesses using the Internet are much more likely to have high-speed access and generally have a positive attitude towards using the Internet. But, these business owners express a preference to control the growth of their business rather than grow the business. Thus, providing high-speed access to rural areas is likely to result in increased usage, but is unlikely to generate higher revenues among the subscribing businesses. Future research should explore reasons for resistance to growth of business.

SEEDS

Publications and Presentations

Sharing knowledge through publications and professional meetings is an important part of research. Using data from SEEDS projects, OARDC scientists have reported the publication of 553 manuscripts, abstracts, and Extension bulletins and more than 1,096 presentations made in various locations throughout the world.



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Presentations

An, R., Sreevatsan, S., and Grewal, P. S. 2006. Poster. Identification of the first two virulence genes of *Moraxella osloensis* in slug *Deroceras reticulatum.* Ohio Agricultural Research and Development Center, Annual Conference, The Ohio State University, Columbus, Ohio, April 20, 2006.

An, R., Sreevatsan, S., and Grewal, P. S. 2005. Podium. Identification of virulence genes of *Moraxella osloensis* in slug *Deroceras reticulatum* using selective capture of transcribed sequences. International meeting of the Society of Invertebrate Pathology, Anchorage, Alaska, August 7-11, 2005.

An, R., Sreevatsan, S., and Grewal, P. S. 2005. Poster. Identification of genes transcribed by *Moraxella osloensis* in slug *Deroceras reticulatum* using selective capture of transcribed sequences. Ohio Agricultural Research and Development Center, Annual Conference, The Ohio State University, Columbus, Ohio, April 21, 2005.

Arvai, J. 2005. Invited Speaker. Improving environmental risk management decisions. Resources for the Future. February 2005, Washington, D.C.

Beck, S. L., and Finer, J. J. 2004. Refining Transient GFP Expression in Lima Bean Cotyledons for Use in an Automated Image Capture and Analysis System. Soy 2004.

Bennett, Mark. 2006 New York Vegetable Conference. Podium. Pepper spacing interactions with crop growth and yield. Syracuse. Feb. 2006. Biennial Meeting of the Molecular and Cellular Biology of the Soybean, Columbia, Mo.

Bonello, P. 2005. Disease resistance mechanisms of pine against *Sphaeropsis* blight and canker. North Central Forest Pest Workshop, La Crosse, Wisc., Sept. 19-22, 2005.

Bonello, P. 2005. Plant-fungus-insect interactions in forest ecosystems. XX Italian Congress of Entomology, Assisi, Italy, June 16, 2005.

Bonello, P. 2005. Plant-Pathogen-Insect Interactions in Forest Ecosystems. Symposium presentation, 20th Italian National Congress of Entomology, Assisi, Italy, June 17, 2005.

Bonello, P. 2005. The nature and ecological implications of disease resistance in pines. Department of Plant Microbiology and Pathology and University of Missouri Center for Agroforestry, University of Missouri, Columbia, Mo., Feb. 2, 2005.

Bonello, P. 2005. Tree-pathogen-insect interactions. Seminar, University of Padua, Italy, June 15, 2005.

Bonello, P. 2006. The nature and ecological implications of disease resistance in pine. University of Florence, Italy, June 22, 2006.

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Cantaneo, A., Loerch, S., Fluharty, F., and Peters, S. 2006. Poster. Stability of vitamin liposomes in rumen fluid. MW Amer. Soc. Animl. Sci. meeting, Des Moines, Iowa, March 2006.

Ceddia, R. P., Wick, M. P., and Ottobre, J. S. 2005. Sodium dependent vitamin C transporter in the sheep *corpus luteum:* sequence analysis. In: Society for the Study of Reproduction 38th Annual Meeting. *Biol. Reprod.* Special Issue. July 24-27, Quebec City, Quebec, Canada. Abstract.

Chi, Y-T, Ling, P. P., and Finer, J. J. 2004. Applying Image Registration to Green Fluorescent Protein Image for Precise Quantification. International ASAE Annual Meeting, Ottawa, Canada.

Chiera, J. M., and Finer, J. J. 2006. Evaluation of an automated image analysis system for factors which stabilize gene expression. Invited speaker to the session, Advances in Plant Transformation. Society for In Vitro Biology Annual Meeting, Minneapolis, Minn.

Darrigues, A., Yang, W., van der Knaap, E., Hogenhout, Saskia, Francis, D. 2006. DNA-Microarray detection of molecular markers for improving color and nutritional quality in tomato. Solanaceae 2006, Madison, Wisc.

Douches, D., De Jong, W., Jansky, S. Spooner, D., Brown, C., Francis, D. 2006. A SolCAP strategy to evaluate allelic diversity of cultivated and wild Solanum germplasm and access economically important genes. Solanaceae 2006, Madison, Wisc.

Fastinger, N. D., Moran, C., and Mahan, D. C. 2006. The effect of steeping and enzyme supplementation of distillers dried grains with solubles on amino acid and energy digestibility in grower-finisher pigs. *J. Animal Science.* Abstract #282.

Fastinger, N. D., and Mahon, D. C. 2005. Apparent and true ileal amino acid and energy digestibility and weaning pig performance of five sources of distillers dried grains with solubles. *J. Animal Science.* Abstract #98.

Finer, J. J., Chiera, J. M., Bouchard, R. A., Park, E. H., Chi, Y-T, Ling, P. P. 2005. Rapid Evaluation of Soybean Promoters Using GFP and an Automated Image Collection and Analysis System. Society for In Vitro Biology Annual Meeting, Baltimore, M.D.

Finer, J. J., Ling, P., Meulia, T., Jones, M. 2004. Promoter Characterization Using Automated Image Analysis. CPBR Symposium, Washington, D.C.

Francis, D., Yang, W., van der Knaap, E., Hogenhout, S. Darrigues, S. DNA-Microarray detection of molecular markers for *S. lycopersicum* x *S. lycopersicum* Crosses. Solanaceae 2005, Bari, Italy.

Francis, D., Yang, W., Van der Knaap, E., Hogenhout, S. Van Deynze, A., Darrigues, A. 2006. DNA-Microarray detection of single feature polymorphisms as a discovery tool for marker assisted selection within elite tomato populations. W299 Plant and Animal Genome Conference, San Diego, Calif.

Francis, D., Yang, W., van der Knaap, E., van Deynze, A., Darrigues, A. 2006. Translational genomics in tomato: marker discovery for breeding. Solanaceae 2006, Madison, Wisc.

Gaddis, J. D., Ottobre, A. C., Dabrowski, K., and Ottobre, J. S. 2002. Poster. Vitamin C depletion and recovery in the ovine *Corpus Luteum* in response to PGF2&#945. Ohio Agricultural Research and Development Center, Annual Conference, Wooster, Ohio.

Geraghty, M. E., Smith, A. M., Walsh, K. R., Monk, P., Hertzler, S., Falla, M. L. 2005. Poster. Fructooligosaccharides (FOS) may increase urinary daidzen in postmenopausal women consuming soy. FASEB J 2005; 19:A449. Experimental Biology Annual Meeting, April 17-21, 2005, San Diego, Calif.

Grewal, P. S., An, R., Sreevatsan, S. 2006. Podium. Virulence of *Moraxella osloensis,* a bacterium associated with the slug-parasitic nematode *Phasmarhanditis hermaphrodita,* to the slug *Deroceras reticulatum.* International Meeting of the Society of Invertebrate Pathology, Wuhan, China, August 27- September 1, 2006.

Heflin, R., Bouchard, B., and Finer, J. J. 2004. Isolation and Partial Characterization of a Soybean HSP90-like Promoter, Soy2004, Biennial Meeting of the Molecular and Cellular Biology of the Soybean, Columbia, Mo.

Gaddis, Janelle, Graduate Student. Second Place Poster in the M.S. student category at the Ohio Agricultural Research and Development Center, Annual Conference, Wooster, Ohio, 2002.

Joshi, R. and McSpadden Gardener, B. 2005. Poster. Identification of DNA markers specific to *Bacillus subtilis* with biocontrol potential using a comparative genomics approach. Ohio Agricultural Research and Development Center, Annual Conference, Columbus, Ohio, April 21, 2005.

Joshi, R., and McSpadden Gardener, B. 2005. Poster. Identification of DNA markers specific to *Bacillus subtilis* with biocontrol potential using an *in vitro* comparative genomics approach. Annual Meeting of the American Phytopathological Society, Austin, Texas, July 30-Aug 3, 2005.

Zeng, Li-Rong, Vega-Sánchez, Miguel E., Chen, Songbiao, and Wang, Guo-Liang. Spotted leaf11 employs a novel mechanism in modulating plant cell death and defense. Presented at the 2006 Plant Molecular Biology and Biotechnology Research Symposium, March 31-April 1, 2006, Wooster, Ohio.

Long, A. and Bomser, J. 2005. Poster. Apoptotic and necrotic mechanisms of stress-induced human lens epithelial cell death. Association for Vision Research and Ophthalmology Meeting, May 1-5, 2005, Ft. Lauderdale, Fla.

McSpadden Gardener, B. 2005. Podium. Biological control of plant pathogens. Allegheny College, Meadville, Pa., April 7, 2005.

McSpadden Gardener, B. 2005. Podium. Identification and use of genetic markers for bacterial biocontrol agents. Eastern Regional Conference on the Ecology of Root-Infecting Microorganisms. Little Rock, Ark., February 8, 2005.

McSpadden Gardener, B. 2005. Podium. Microbial ecology research to expand and improve biological control of plant diseases. Teleconference-based seminar to Becker Underwood LLC, Ames, Iowa, November 15, 2005.

McSpadden Gardener, B. 2006. Podium. Academic point of view on commercial product development and field testing. Becker Underwood LLC, Technical Collaborators Forum, March 3, 2006.

McSpadden Gardener, B. 2006. Podium. Investigating *Bacillus* spp.: Diversity, biogeography, and mechanisms of biocontrol — MPMI@OSU (A semiannual interdepartmental gathering of scientists interested in plant-microbe interactions), Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, Ohio, March 31, 2006.

McSpadden Gardner, B. 2005. Evaluation of induced resistance as a mechanism for controlling anthracnose fruit rot in fresh market tomatoes. The 2005 Ohio Fruit and Vegetable Grower's Congress, the North Central APS meeting, Toledo, Ohio, January 19-21, 2005.

Precheur, R., and Jasinski, J. 2006. Ohio Fruit and Vegetable Congress, Columbus Convention Center, Columbus, Ohio, January 16-18, 2006.

Van Deynze, A., Van der Knaap, E., Francis, D. 2006. Development and application of an informative set of anchored markers for tomato breeding. P188 Plant and Animal Genome Conference, San Diego, Calif., January 14-18, 2006.

Wallis, C. M., Eyles, A., Chorbadjian, R., Hansen, R., Cipollini, D. F., Herms, D. A., and Bonello, P. 2006. Relationships of phloem chemistry with systemic resistance to *Sphaeropsis sapinea* in Austrian pine subjected to different fertility levels and insect defoliation. In: Southwide and Northeast Forest Disease Workshops, Davis, W. Va., June 20-22, 2006.

Yuan, L., Rao, S., Azevedo, M. S. P, Azevedo, A. S. P., Patton, J. T., Hoshino, Y., and Saif, L. J. Sequence analysis of rearranged RNA segments 5, 7, and 8 of attenuated Wa strain human rotavirus. Abstract PW4.11. 9th dsRNA Virus Symposium. Cape Town, South Africa, October 21-26, 2006. National Breeders Roundtable, "Mechanisms of Muscle Growth: Why does the Poultry Industry Need to be Concerned," St. Louis, Mo., May 2006.

Graduate Students

Chi, Y-T. Master of Science. *A Machine Vision-Based Green Fluorescence Protein Quantification System.* Food, Agricultural, and Biological Engineering. 2004.

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